PROC. BIOL. SOC. WASH.
100(4), 1987, pp. 1040–1048

A NEW TROGLOBITIC CRAYFISH FROM NORTHWESTERN ARKANSAS (DECAPODA: CAMBARIDAE)

Horton H. Hobbs, Jr., and Arthur V. Brown

Abstract.—A new troglobitic crayfish, *Cambarus* (*Jugicambarus*) *aculabrum,* is described from two cave streams in Benton County, Arkansas. Its closest affinities are with three other troglobitic species occurring in the Ozark region: *C.* (*J.*) *zophonastes* from Arkansas, *C.* (*J.*) *setosus* from Missouri, and *C.* (*J.*) *tartarus* from Oklahoma.

The crayfish described herein from Benton County, Arkansas, is the second troglobitic decapod to be reported from the state. Only the rare *Cambarus* (*Jugicambarus*) *zophonastes* Hobbs and Bedinger (1964:11), known from a single locality (Hell Creek Cave) in Stone County, has been found previously. Two additional closely related albinistic species, however, occur in the Ozark region: *C.* (*J.*) *setosus* Faxon (1889:237) in southern Missouri, and *C.* (*J.*) *tartarus* Hobbs and Cooper (1972:51) in eastern Oklahoma. The more distantly related troglobitic *C.* (*J.*) *cryptodytes* Hobbs (1941:110) frequents subterranean waters of the panhandle of Florida and southwestern Georgia. (For a review of what is known about these crayfishes, see Hobbs, Hobbs, and Daniel 1977.) Features that will aid in distinguishing between them are pointed out in the appended key and are illustrated in Fig. 2.

Cambarus (*Jugicambarus*) *aculabrum,* new species

Figs. 1a–l, 2a–c, e, j, n

Diagnosis.—Body and eyes without pigment, latter reduced. Body and chelipeds studded with conspicuous stiff setae. Rostrum usually with small marginal spines, occasionally tapering to apex without setting off distinct angle at base of acumen. Areola 17.5 to 54.5 times as long as wide, comprising 43.2 to 47.2 percent of entire length of carapace (50.3 to 55.3 percent of postorbital length), and with 1 or 2 punctations in narrowest part. Cervical spines minute; suborbital angle lacking; postorbital ridges reduced but sometimes with very small, corneous apical tubercles. Antennal scale 1.7 to 1.8 times as long as wide, broadest distinctly distal to midlength. Chela with subrectangular palm bearing irregular mesial arrangement of 20 to 25 tubercles; longitudinal ridges of fingers well developed. Hooks on ischia of third pereiopods of male distinctly compressed, not reaching basioischial articulation, and not opposed by tubercle on basis. First pleopod of first form male with rather long, strongly recurved, scythe-like central projection bearing distinct subapical notch; mesial process appearing somewhat degenerate, not inflated, with basal part of distal (morphological cephalic) margin shallowly concave, and disposed at about 120 degrees to shaft of appendage; proximolateral lobe not set off from shaft by groove. Annulus ventralis subsymmetrical in outline, caudal part slightly movable; cephalic half traversed by deep submedian longitudinal trough; sinus originating on caudolateral (either right or left) side of trough from which coursing caudomesially and, crossing median line, continuing to fossa, and from latter turning

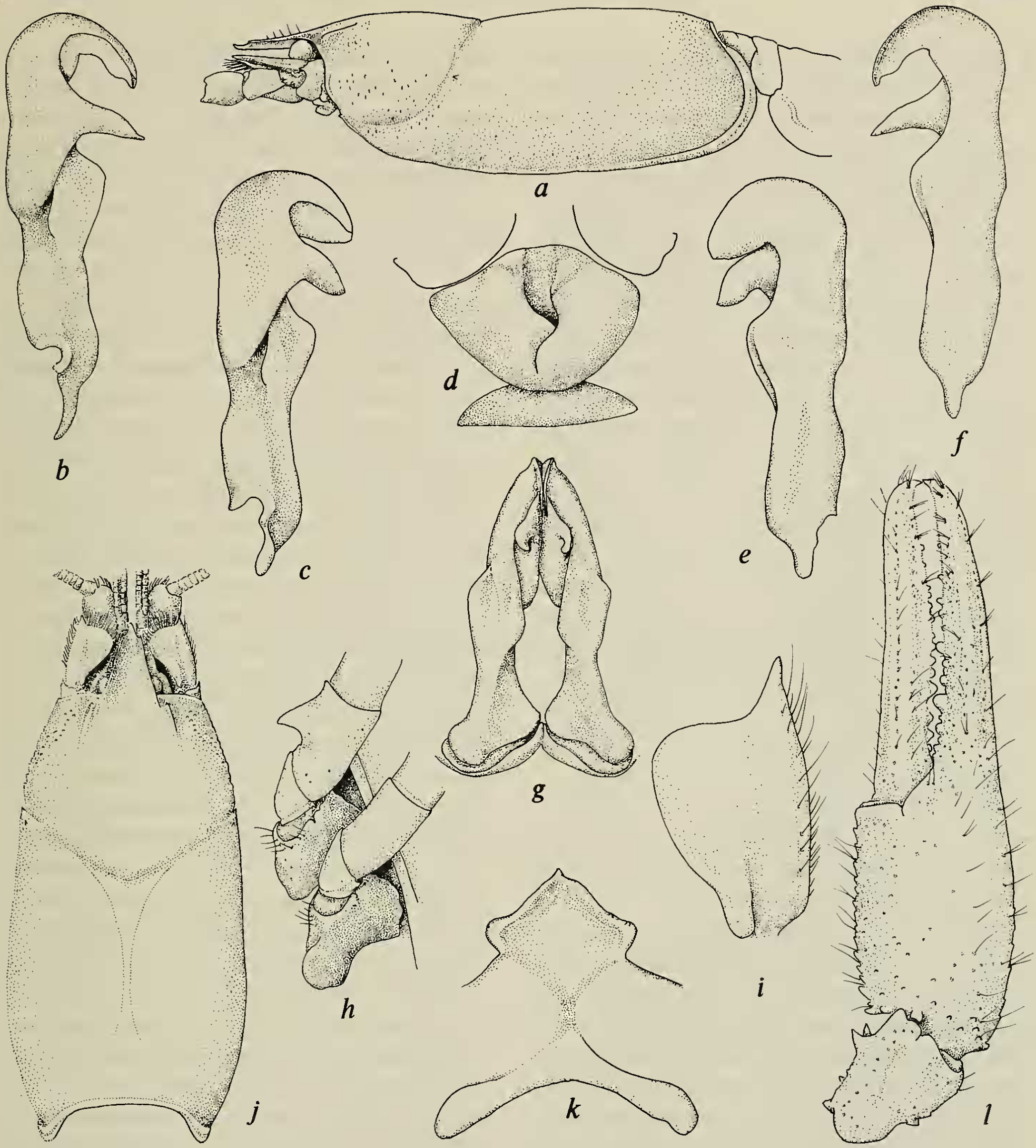


Fig. 1. *Cambarus* (*J.*) *aculabrum* (a, b, f–l from holotype; c, e from morphotype, and d from allotype): a, Lateral view of cephalothorax; b, c, Mesial view of first pleopod; d, Annulus ventralis; e, f, Lateral view of first pleopod; g, Caudal view of first pleopods; h, Ventral view of basal podomeres of third and fourth pereiopods; i, Right antennal scale; j, Dorsal view of carapace; k, Epistome; l, Dorsal view of distal podomeres of cheliped.

gently to median line where, after following it for short distance, ending on caudal wall of annulus. First pleopod of female represented by minute tuberculiform papilla.

Holotypic male, form I: Body subovate, strongly depressed (Figs. 1a, j). Abdomen narrower than thorax (9.1 and 11.6 mm). Areola narrow, 36.7 times as long as wide, with 1 punctation in narrowest part; length of areola 45.8 percent of entire length of carapace (53.9 percent of postorbital length). Rostrum with weakly thickened, elevated, strongly convergent borders bearing minute corneous tubercles at base of acumen; latter with upturned corneous tip overreaching base of ultimate podomere of antennular peduncle; upper surface of rostrum shallowly concave and bearing setiferous punctations, those on mesial flank of both borders deep. Subrostral ridge well developed and evident in dorsal aspect along basal half of rostrum. Postorbital ridges weak, deeply grooved dorsally, and dextral member with small corneous tubercle on cephalic extremity. Suborbital angle absent; branchiostegal spine small. Cervical spine also small but with acute, corneous tip. Carapace conspicuously punctate dorsally; hepatic, mandibular, and anteroventral branchiostegal regions tuberculate, most of branchiostegites granular; majority of punctations and granules supporting setae, many of which erect.

Abdomen and carapace subequal in length (24.1 and 24.0 mm); pleura rather short and rounded ventrally. Cephalic section of telson with two spines in each caudolateral corner, more mesial one movable. Proximal podomere of uropod with acute spine on mesial lobe; mesial ramus with moderately well developed median keel terminating distally in small premarginal spine; spine also present on distolateral angle.

Cephalic lobe of epistome (Fig. 1k) subtriangular with acute anteromedian angle, anterolateral margins elevated (ventrally), dextral one bearing 2 small tubercles; main body of epistome with longitudinal median trough lacking well-defined fovea, but distinct oblique ridge (not illustrated) extending anterolaterally from lateral extremity of arched zygoma. Basal segment of antennule with well developed spines lightly mesial to median line at base of distal third of podomere. Antennal flagellum broken. Antennal scale (Fig. 1i) decidedly wide, broadest distal to midlength; thickened lateral part terminating distally in acute, corneous-tipped spine overreaching tip of acumen and almost attaining distal extremity of antennular peduncle.

Right chela (Fig. 1l) little more than 3.5 times as long as wide, slightly depressed, and with subrectangular palm; mesial margin of palm with about 24 tubercles arranged roughly in 2 staggered rows and many with long, stiff setae extending from their distal bases; base of palm with irregular row of 9 or 10 tubercles extending transversely from ventrolateral condyle across lateral and dorsal surfaces to level of dorsomesial condyle; ventrodistal surface of palm with 3 submedian tubercles: 2 on proximal flank of oblique ridge and 1 proximal to them; lateral margin with row of low tubercles along proximal half and setiferous punctations distally; almost all punctations and tubercles on palm and fingers supporting long stiff setae. Opposable margin of fixed finger with 2 rows of tubercles: dorsal row consisting of 9 on proximal half and 2 minute ones (too small to include in illustration) in distal third; ventral row of 5 beginning just proximal to midlength of finger and extending to base of distal fourth; tubercles of both rows with corneous tips; single row of minute denticles extending almost entire length of finger between dorsal and ventral rows of tubercles. Opposable margin of dactyl with single row of 16 tubercles along proximal four-fifths of finger interspersed among single row of minute denticles; all tubercles, except for abraded ones, with corneous tips. Dorsal and ventral surfaces of both fingers with well developed longitudinal ridges; mesial margin of dactyl with conspicuous setiferous punctations.

Carpus of cheliped longer than broad (5.6 and 4.2 mm) with shallow, oblique furrow dorsally; mesial surface with 2 large spike-like tubercles situated distal to 3 much smaller ones; ventral surface with 3 tubercles on distal border, middle one smaller than others, mesial one largest; lateral surface with oblique row of several small tubercles and few others more proximally situated, 2 somewhat dorsally and 1 ventrally; podomere otherwise bearing setiferous punctations.

Dorsal surface of merus with single row of tubercles basally, but tubercles forming distally broadening band beyond midlength; ventral surface with mesial and lateral rows of 15 tubercles each, those in distal half of both rows spikelike. Mesial and lateral surfaces punctate, and distolateral extremity with single spikelike tubercle. Ischium with ventromesial row of 4 small tubercles distal to fracture suture.

Hook present on ischium of third pereiopod only (Fig. 1h); hook strongly compressed and not reaching basioischial articulation and not opposed by tubercle on basis. Coxa of fourth pereiopod with rounded, somewhat compressed caudomesial boss. Coxa of fifth pereiopod without prominences. For measurements see Table 1.

First pleopods (Figs. 1b, f, g) reaching coxae of third pereiopods when abdomen flexed. See "Diagnosis" for description.

Allotypic female: Differing from holotype in other than secondary sexual features in following respects: acumen almost reaching distal margin of penultimate podomere of antennular penduncle; postorbital ridges with minute, corneous apical tubercle; right cervical spine reduced to small tubercle; abdomen longer than carapace, and pleura more flared; both anterolateral margins of cephalic lobe of epistome with 2 tubercles, dextral with rudimentary third one, and most anterior one situated adjacent to rounded apex of lobe; oblique lateral ridge of main body of epistome with small spine at lateral extremity; antennal flagellum also broken but reaching fifth abdominal tergum; mesial margin of palm of right chela with 18 tubercles (left with 20) arranged in 2 rows; ventrodistal surface of palm with 1 (right) or 2 (left) tubercles; opposable margin of fixed finger of right cheliped with 6 tubercles (8 on left) in dorsal row and 3 (4 on left) in ventral row; opposable margin of dactyl with row of 10 (9 on left); mesial surface of right carpus with 1 spikelike tubercle and 6 smaller ones (left with 1 and 4); merus of right cheliped with ventrolateral row of 11 tubercles and ventromesial one of 16 (most spikelike); ischium of both chelipeds with ventromesial row of 3 small tubercles distal to fracture suture.

Table 1.—Measurements (mm) of *Cambarus* (*J.*) *aculabrum*.

	Holotype ♂ I	Allotype, ♀	Morphotype, ♂ II	Topotype ♂ I
Carapace:				
Entire length	24.0	23.8	19.7	23.1
Postorbital length	20.4	20.8	17.7	19.7
Width	11.6	11.8	9.9	11.6
Height	7.7	7.3	7.1	8.4
Areola:				
Width	0.3	0.2	0.2	0.3
Length	11.0	10.9	8.9	10.9
Rostrum:				
Width	2.7	2.8	2.5	2.6
Length	3.9	3.6	3.3	3.3
Chela:				
Length, palm mesial margin	8.9	8.9	7.5	7.9
Palm width	6.7	7.5	6.1	6.5
Length, lateral margin	24.7	23.5	20.0	22.4
Dactyl length	14.3	13.1	11.2	13.0
Abdomen:				
Width	9.1	10.3	7.9	9.3
Length	24.1	25.6	22.0	25.1

Annulus ventralis (Fig. 1d; see also Fig. 2n) as described in "Diagnosis."

Morphotypic male, form II: Differing from holotype in following respects: acumen falling short of midlength of ultimate podomere of antennular peduncle; postorbital ridges very poorly developed and neither with tubercle at cephalic extremity; abdomen longer than carapace; antennal scale with distolateral margins more concave, and left basal angle with small tubercle, distolateral spine reaching distal extremity of antennular peduncle; ventrodistal surface of palm of right chela with single tubercle on proximal flank of oblique ridge, left as in holotype; opposable margin of fixed finger of right chela with 6 tubercles in dorsal row and 3 in ventral (left chela with 6 and 2); opposable margin of dactyl with row of 10 tubercles on right chela and 13 on left; ventral surface of merus of right cheliped with 11 tubercles in lateral row and 13 in mesial (14 in each row on left); tubercles in ventromesial row of ischium very small. Typically, hook on ischium of third pereiopod smaller but otherwise similar to that in holotype. First pleopod (Fig. 1c, e) with terminal elements more robust but disposed almost as in holotype, although mesial process more strongly reflexed.

Type locality. — Logan Cave, about 11 km east of Shiloam Springs, Benton County, Arkansas (Gallatin Quadrangle T. 18N, R. 32W, Sec. 33; 36°11′50″N, 94°22′50″W). This Ozarkian solution channel, located in the Mississippian cherty-limestone Boone Formation of the Springfield Plateau, is approximately 2000 m long. Water flows (about 19,000 m^3/day) through the entire length of the cave and forms a brook where it surfaces at an elevation of about 323 m. A conical sink hole (10 m diameter × 10 m deep) provides a second access to the passageway about 300 m upstream from that at the spring opening. Collapse of the cave roof formed the sink and dammed the stream, creating an underground lake about 200 m long, 2–6 m wide, and 2–3 m deep. Most of the *Cambarus* (*J.*) *aculabrum* have been seen in this pool, but they also occur in other reaches of the stream. They are usually found along the side walls of the pool or at the margin of the stream. As many as six have been seen during one survey, but more often not one is in evidence. The cave contains a diverse array of other species including among the aquatic forms, an epigean crayfish, *Orconectes neglectus neglectus* (Faxon); Ozark cavefish, *Amblyopsis rosae* (Eigenmann); isopods, *Caecidotea stiladactyla* Mackin and Hubricht; amphipods, *Stygobromus ozarkensis* (Holsinger); sculpins, *Cottus carolinae* Gill, and salamanders, *Typhlotriton spelaeus* (Stejneger), *Eurycea lucifuga* Rafinesque, *E. longicauda* (Green), and *E. multiplicata* (Cope). Terrestrial cave inhabitants include a large population of gray bats, *Myotis grisecens* Howell, other bats, e.g., *Pipistrellis subflavus* Cuvier, collembolans, beetles, dipterans, millipedes, and pseudoscorpions.

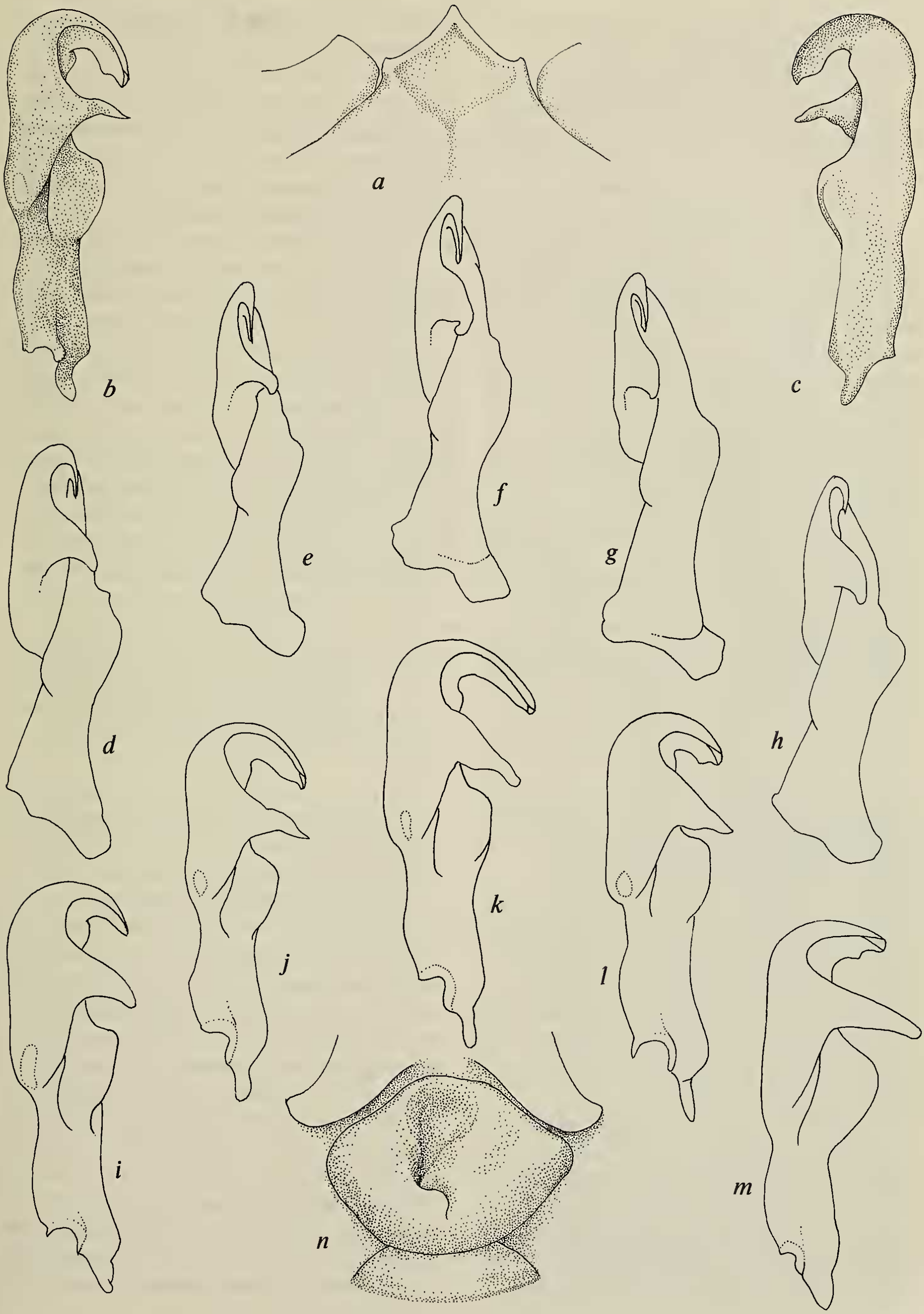
Disposition of types. — The holotype, allotype, and morphotype are deposited in the National Museum of Natural History (Smithsonian Institution), numbers 219149, 219150, 219151, respectively. Paratypes, consisting of 1 ♂ I from Logan Cave, and 3 ♂ I, 3 ♂ II, and 1 ♀ from Bear Hollow Cave (see "Range"), are also in the Smithsonian Institution.

Size. — The largest specimen available is a female from Bear Hollow Cave possessing a carapace length of 28.2 mm (postorbital carapace length, 24.0 mm). The largest (the holotype) and smallest first form males have corresponding lengths of 24.0 (20.4) mm and 16.2 (13.7) mm, respectively.

Range. — This crayfish is known from only two localities, both in Benton County, Arkansas; the type locality and Bear Hollow Cave which is situated about 38 km NNW of Logan Cave (T. 21N, R. 30W, Sec. 18; 36°29′50″N, 94°13′25″W). The latter cave is also a solution tunnel in the Boone Formation, but the opening on the hillside is at an elevation of 1160 feet (354 m) and the small stream in it no longer discharges at the surface. There is less habitat available in the much smaller stream (about 200 m long and 0.2 m deep) in Bear Hollow Cave than in the type locality, but as many as nine crayfish have been seen during a single survey. The cave fauna is much less diverse than that in Logan Cave, probably reflecting

⟶

Fig. 2. Epistome and secondary sexual features of troglobitic members of subgenus *Jugicambarus* (a, epistome; b, i–m, mesial view of first pleopod of first form male; c, lateral view of same; d–h, caudal view of same; n, annulus ventralis): a–c, n, Paratypes of *C.* (*J.*) *aculabrum* from Bear Hollow Cave; d, i, Holotype of *C.* (*J.*) *zophonastes*; e, j, Holotype of *C.* (*J.*) *aculabrum*; f, k, *C.* (*J.*) *setosus* from Smallins Cave; g, l, Holotype of *C.* (*J.*) *tartarus*; h, m, Holotype of *C.* (*J.*) *cryptodytes*.


a
b
c
d
e
f
g
h
i
j
k
l
m
n

the lower energy source resulting from the absence of a large colony of bats.

Seasonal data.—First form males were obtained on 31 December 1985, 16 January 1986, 20 February 1986, 8 October 1986, and 25 February 1987. Females carrying eggs or young have not been observed.

Variations.—The most striking variations noted are in the shape and degree of development of the marginal tubercles of the rostrum, the ornamentation of the anteromedian lobe of the epistome, and in the relative width of the areola. The rostral margins may converge almost from the level of the orbit to the base of the acumen, or they may be subparallel or even slightly convex laterally. Moderately well developed marginal tubercles may mark the base of the acumen, but they may be minute, and occasionally are absent (perhaps resulting from injury in an earlier instar) and the angle missing at the base of the acumen. The anteromedian lobe of the epistome is basically in the form of an isosceles triangle with a relatively broad base; however, the anterolateral sides may be slightly concave, unevenly and asymmetrically crenate, and in at least one specimen the anterolateral angles are produced anteriorly (Fig. 2a); in all of the specimens examined, however, there exists an anteromedian, subacute angle. As pointed out above, the width of the areola is decidedly variable, ranging from 17.5 to more than 50 times as long as broad. Other variations occur in the numbers of tubercles on the several podomeres of the cheliped, but they scarcely extend the range of numbers noted in the descriptions of the primary types. Compare Figure 1b, f with 2b, c.

The populations in the two caves seem consistently to differ in two respects: specimens from the type locality exhibit rostra with more strongly convergent lateral margins than do those from Bear Hollow Cave; also, the areola is proportionately narrower (36.3 to 54.5, avg. 43.0 times as long as wide, n = 4) than that in specimens from the latter (17.5 to 35.3, avg. 26.8, n = 7).

Relationships.—There is every reason to believe that the four troglobitic crayfishes of the Ozark Region are more closely allied to one another than any one is to other troglobitic or epigean species. They resemble each other so closely, and the ranges of variation are so similar that one is almost forced to conclude that, unlike the troglobitic *Procambarus* in Florida in which at least three separate origins from epigean ancestors were postulated by Hobbs and Franz (1986), they appear to have been derived from a single stock that gained access to an early subterranean channel in the Ozark uplift. In this stock, a mien that was to become characteristic of all of the troglobitic *Jugicambarus* now known to inhabit the subterranean waters of the Ozark region was soon acquired. The features contributing to the existing similarities are apparently so much in accord with the similar environments in which subsequent isolated populations have become established that few consistently unique qualities, except in secondary sexual characters of the males, can be found in any of them.

The only local clues as to the nature of the ancestral epigean stock that entered the Ozark region must be sought in the very poorly known *C.* (*J.*) *causeyi* (Reimer 1966: 9). But, like its troglobitic relatives, this relict has become so highly adapted (burrowing in seepage areas and in the substrate of small headwater streams) that surely its physiognomy is unlikely to reflect many ancestral qualities of the early epigean Ozarkian *Jugicambarus* stock any better than do those of the troglobites. For example, its strongly compressed body is unique in the subgenus, and few other members of *Cambarus* appear to be so slender. Likely a better appreciation of the visage of the most recent epigean antecedent of the troglobites might be gained by turning to the stream-dwelling *Jugicambarus* frequenting the Cumberland

Plateau and Highland Rim of Tennessee and Kentucky. Perhaps surprising is the observation that marginal spines or tubercles on the rostrum, considered generally to be a primitive feature in crayfish lineages, are lacking in all *Jugicambarus* except the Ozarkian troglobites! Does their presence in these cave dwellers represent a primitive retention or an atavistic recurrence?

Two features seem consistently to set *C.* (*J.*) *aculabrum* apart from its close relatives. The anteromedian lobe of the epistome is produced anteriorly in an acute or subacute apex, hence the name accorded the species, and the first pleopod, which lacks even a trace of a groove at the base of the proximolateral lobe, exhibits a strongly reflexed, distally tapering central projection that bears a shallow subapical notch. The following key should aid in the identification of the first form males of the five troglobitic members of the subgenus *Jugicambarus.*

Key to the Troglobitic Members of the Subgenus *Jugicambarus* (Based on first pleopods of first form males)

1. Central projection directed at right angle to shaft of appendage (Fig. 2h, m) . . . . *C.* (*J.*) *cryptodytes*
– Central projection bent more than at right angle to shaft of appendage (Fig. 2i–l) 2
2. Proximolateral lobe of first pleopod set off from shaft by shallow or deep transverse groove (Fig. 2f, g) 3
– Proximolateral lobe of shaft of first pleopod not set off from shaft by transverse groove (Figs. 2d, e) 4
3. Central projection short, not tapering, truncate apically (Fig. 2g, l) . . . . *C.* (*J.*) *tartarus*
– Central projection moderately long, and tapering to rounded apex (Fig. 2f, k) . . . . *C.* (*J.*) *setosus*
4. Central projection short and lacking subapical notch (Fig. 2d, i) . . . . *C.* (*J.*) *zophonastes*
– Central projection moderately long and with shallow subapical notch (Fig. 2e, j) . . . . *C.* (*J.*) *aculabrum*

Acknowledgments

We extend our thanks to C. Stanley Todd for the interest, enthusiasm, and assistance provided during the course of a study, by one of us (AVB), of the Ozark caves and their faunas. His help in obtaining the series of specimens on which this report is based was invaluable. We are also grateful to the Arkansas Nongame Preservation Committee for a grant that made the cave study possible. For their comments and criticisms of the manuscript, appreciation is extended to Thomas E. Bowman of the Smithsonian Institution, J. F. Fitzpatrick, Jr., of the University of South Alabama, and H. H. Hobbs, III of Wittenberg University. We also appreciate the assistance of Mark E. Gordon with various aspects of the study.

Literature Cited

Faxon, Walter. 1889. *Cambarus setosus* Faxon. *In* Samuel Garman, Cave animals from southwestern Missouri.—Bulletin of the Museum of Comparative Zoology at Harvard College 17(6): 237, pl. 1: figs. 1–3; pl. 2: fig. 1.

Hobbs, Horton H., Jr. 1941. Three new Florida crayfishes of the subgenus *Cambarus* (Decapoda, Astacidae).—American Midland Naturalist 26(1):110–121, 2 pls.

———, and M. S. Bedinger. 1964. A new troglobitic crayfish of the genus *Cambarus* (Decapoda, Astacidae) from Arkansas with a note on the range of *Cambarus cryptodytes* Hobbs.—Proceedings of the Biological Society of Washington 77(3): 9–15, 11 figs.

———, and Martha R. Cooper. 1972. A new troglobitic crayfish from Oklahoma (Decapoda: Astacidae).—Proceedings of the Biological Society of Washington 85(3):49–56. 1 fig.

———, and Richard Franz. 1986. New troglobitic crayfish with comments on its relationship to epigean and other hypogean crayfishes of Florida.—Journal of Crustacean Biology 6(3):509–519, 2 figs.

———, H. H. Hobbs, III, and Margaret A. Daniel. 1977. A review of the troglobitic crustaceans of the Americas.—Smithsonian Contributions to Zoology 244:v + 183 pp, 70 figs.

Reimer, Rollin DeWayne. 1966. Two new species of the genus *Cambarus* from Arkansas (Decapoda, Astacidae).—Tulane Studies in Zoology 13(1): 9–15, 18 figs.

(HHH) Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560; (AVB) Department of Zoology, University of Arkansas, Fayetteville, Arkansas 72701.